The Impact of Unmanned Aerial Systems on Joint Operational Art

A Monograph
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AY 2012-001

REPORT DOCUMENTATION PAGE	Form Approved OMB No. 074-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	15 May 2012	SAMS Monograph July 2011 - May 2012

4. TITLE AND SUBTITLE

The Impact of Unmanned Aerial Systems on Joint Operational Art

5. FUNDING NUMBERS

6. AUTHOR(S)

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Major, United States Air Force

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

School of Advanced Military Studies (SAMS)
250 Gibbon Avenue
Fort Leavenworth, KS 66027-2134

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Command and General Staff College
731 McClellan Avenue
Fort Leavenworth, KS 66027-2134

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT	12b. DISTRIBUTION CODE
Approved for Public Release; Distribution is Unlimited	

13. ABSTRACT ***(Maximum 200 Words)***

The use of Unmanned Aerial Systems (UAS) by the United States (US) military has expanded significantly during the last twenty years. Operations in Afghanistan and Iraq in particular have cemented their place in the military's force structure. This monograph examines the history, contemporary operations, and future vision of UAS development and operations to quantify how UAS affect operational art for air, land, and maritime forces. The USAF and various agencies of the strategic intelligence community dominate UAS operations and development in the air domain. These professionals historically develop highly sophisticated, capable, and expensive systems, and make little distinction between aircraft based being manned or unmanned. Because of that, their operational approach for UAS employment does not vary significantly from that of manned aircraft. However, because UAS operations are not as politically sensitive as manned aircraft, airmen have a history of operating them in third party countries and are thus able to extend operational reach. The US Army and US Marine Corps (USMC) dominate UAS development and operations by land forces. Soldier and marines focus on using UAS to support tactical ground maneuver and fires units by providing Intelligence, Surveillance, and Reconnaissance (ISR) to tactical ground commanders. This helps these commanders improve their operational tempo by making better decisions faster. However, operations in Afghanistan and Iraq demonstrate how the large quantity of information produced by UAS have a degree of friction that can actually slow down operational tempo. The US Navy (USN) dominates development and operations of UAS for maritime forces, and historically focuses on using unmanned systems in support of

14. SUBJECT TERMS	15. NUMBER OF PAGES
UAS, UAV, Operational Art	52
	16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
(U)	(U)	(U)	

SCHOOL OF ADVANCED MILITARY STUDIES

MONOGRAPH APPROVAL

Maj Joel E. Pauls

Title of Monograph: The Impact of Unmanned Aerial Systems on Joint Operational Art

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Abstract

The Impact of Unmanned Aerial Systems on Joint Operational Art by Major Joel E. Pauls, USAF, 52 pages.

The use of Unmanned Aerial Systems (UAS) by the United States (US) military has expanded significantly during the last twenty years. Operations in Afghanistan and Iraq in particular have cemented their place in the military's force structure. This monograph examines the history, contemporary operations, and future vision of UAS development and operations to quantify how UAS affect operational art for air, land, and maritime forces. The USAF and various agencies of the strategic intelligence community dominate UAS operations and development in the air domain. These professionals historically develop highly sophisticated, capable, and expensive systems, and make little distinction between aircraft based being manned or unmanned. Because of that, their operational approach for UAS employment does not vary significantly from that of manned aircraft. However, because UAS operations are not as politically sensitive as manned aircraft, airmen have a history of operating them in third party countries and are thus able to extend operational reach. The US Army and US Marine Corps (USMC) dominate UAS development and operations by land forces. Soldier and marines focus on using UAS to support tactical ground maneuver and fires units by providing Intelligence, Surveillance, and Reconnaissance (ISR) to tactical ground commanders. This helps these commanders improve their operational tempo by making better decisions faster. However, operations in Afghanistan and Iraq demonstrate how the large quantity of information produced by UAS have a degree of friction that can actually slow down operational tempo. The US Navy (USN) dominates development and operations of UAS for maritime forces, and historically focuses on using unmanned systems in support of utility missions and naval gunfire support. Until recently, the USN did not attempt to develop UAS for carrier operations, which presents a potential risk to the USN's ability to project force into the operating environment defined by the Department of Defense's *Joint Operational Access Concept.*

A Joint Force Commander in command of these components is able to extend operational reach, operate at a faster tempo, and reduce risk to both the force and the mission because of UAS. However, because of the different perspectives on UAS by the various components, command and control (C2) challenges exist. Additionally, the massive quantity of information produced by UAS can have negative effects if that information is not properly analyzed and distributed. UAS, like any other instrument of warfare, are only as effective as the military professional that operates them.

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Introduction

The use of unmanned aircraft in the United States (US) military has only gained prominence in the last twenty years, but its history is much more extensive. During World War II (WWII), General Hap Arnold recognized the lifesaving potential of unmanned aircraft, and converted battle-worn B-17s and B-24s into remotely piloted strike aircraft.[1] While the Army Air Forces designed these initial unmanned systems for lethal attacks, reconnaissance and surveillance requirements drove unmanned aircraft development during the Cold War. Operation DESERT STORM marked the first time all four services employed unmanned aircraft at various levels and for multiple purposes, paving the way for operations in Afghanistan and Iraq a decade later.[2]

During Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF), unmanned aircraft came of age. For the first time, unmanned aircraft were a critical part of planning efforts from the inception of military operations. Unmanned aircraft provided a critical Intelligence, Surveillance, and Reconnaissance (ISR) capability, and were in such demand that they grew exponentially throughout the joint force. Additionally, during OEF and OIF, unmanned aircraft began a transformation from being ISR platforms, for the most part, to multi-mission aircraft with lethal capabilities as well.

The significance of unmanned aircraft in contemporary operations is easy to see by imagining a day without them. Tactical ground units would lose critical organic ISR capabilities, while political leaders would lose a key weapon in global counter terrorism operations. Additionally, regardless of its effect (strategic, operational, or tactical), unmanned aircraft appear to provide many traditional capabilities while reducing risk when compared to manned aircraft

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[1] Thomas P. Ehrhard, *Air Force UAVs: The Secret History* (Mitchell Institute, July 2010), 2.

[2] John D. Blom, *Unmanned Aerial Systems: A Historical Perspective* (Fort Leavenworth, KS: Combat Studies Institute Press, 2010), 2.

operations. This is not only realized by the absence of exposing human operators to threats, but also in the reduced need for supporting operations like search and rescue.

However, if unmanned aircraft have unique capabilities, when compared to manned aircraft, do operational commanders employ them differently? In short, how do unmanned aircraft impact joint operational art in the US military? This monograph concludes that unmanned aircraft facilitate a faster operational tempo and extend operational reach, while reducing risk to both the forces and the mission. This gives commanders an advantage that helps them seize and maintain the initiative while connecting tactical actions in time, space, and purpose, to achieve operational and strategic objectives.

This monograph uses a case study methodology, and examines historical context, contemporary operations, and future vision of unmanned aircraft operations from the perspectives of the air, land, and maritime domains. While the history of unmanned aircraft in the military begins in the early 20th century, the historical analysis within this monograph is limited to the post-WWII era. It is sub-divided into spans of time characterized by early Cold War, Vietnam War era, post-Vietnam War through the 1980s, and post-Cold War to 9/11. The contemporary operations section specifically focuses on military operations after 9/11. Finally, the future vision section examines the plans for unmanned aircraft development out to the 2020-2025 timeframe. This analysis provides evidence to support conclusions about how unmanned aircraft affect operational art from an individual domain perspective. The conclusion integrates these three viewpoints and seeks to answer the research question from the perspective of the Joint Force Commander (JFC).

The study of unmanned aircraft is complicated because of the various names and terms that attempt to provide an adequate description. During WWII, the military used the term drone to describe remotely piloted aircraft primarily used for target practice. As the military specifically designed unmanned aircraft to fly operational missions, they became known as Remotely Piloted Vehicles (RPV). However, by the 1980s many of these aircraft operated autonomously, therefore, the term RPV was misleading. The term Unmanned Aerial Vehicle (UAV) entered the military lexicon in the 1980s, and remains an effective description of an individual aircraft.[3] However, the term UAV does not encompass the broader control systems and mechanisms required to operate an unmanned aircraft. Unmanned Aerial Systems (UAS) include one or several UAVs, the data link system, the ground control systems, the on-board sensors, and the data processing terminal. Often times the greatest challenge and highest cost associated with UAS operations is not the actual aircraft, but the sensor array and associated data link. The distinction between drone, RPV, and UAV is not substantial. On the other hand, the difference between UAV and UAS is significant.[4]

Additionally, there are various ways of describing the functionality of UAS. Historically, terms like tactical or strategic get associated with aircraft based on the type of mission they were designed for. For example, the B-52 is a strategic bomber. This is also true for UAS, and for land forces, this naming convention extends to type of unit the UAS supports. Subsequently, OEF and OIF had strategic bombers doing tactical missions like Close Air Support (CAS). This highlights the broader notion that air power is capable of producing tactical, operational, and strategic effects near simultaneously, shifting the emphasis away from a specific aircraft.[5] However, this method of classification was inadequate for UAS because of the wide variety of capability that exists between aircraft like the Shadow and the Global Hawk. Therefore, some propose that UAS should be thought of in terms of capability to operate throughout a theater, or with in a local area. This method further promotes the centralized control of all theater capable platforms.[6] Finally, the Department of Defense (DOD) published guidance that classifies UAS into five categories based

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[3] Bill Yenne, *Attack of the Drone* (St. Paul, MN: Zenith, 2004), 13.

[4] Blom, 2-3.

[5] US Air Force, Air Force Doctrine Document 1, *Air Force Basic Doctrine, Organization, and Command* (Washington, D.C.: 14 October 2011), 39-40.

[6] David A. Deptula, "Unmanned Aircraft Systems: Taking Strategy to Task," *Joint Forces Quarterly* 49, April 2008, 50.

on performance. Group 1 and 2 (Shadow and Scan Eagle) aircraft are small, tactical UAS as they fly at low altitudes and slow speeds, and are generally organic in smaller ground units. Group 3 UAS are larger, and capable of operating above coordinating altitudes (RQ-7B), but still not thought of as being capable of operating across a theater of operation. Additional size and speed, and the higher operating altitudes of medium sized Group 4 UAS set them apart from the first three (Predator being the most notable), making them theater capable aircraft. Finally, Group 5 represents the largest, most sophisticated, high performance UAS in the inventory (Global Hawk).[7] Each type of description has value, and all are used throughout this monograph.

Finally, the term operational art has several meanings that require clarification. Joint doctrine describes operational art as "The cognitive approach by commanders and staffs—supported by their skill, knowledge, experience, creativity, and judgment—to develop strategies, campaigns, and operations and organize and employ military forces by integrating ends, ways, and means."[8] Each service also defines operational art. Almost all talk about linking ends, ways, means, and risk in an overall campaign.[9] Therefore, for the sake of this monograph, operational art refers to linking tactical actions in time, space, and purpose, to achieve strategic objectives.

Air Component

The USAF, in conjunction with various agencies of the strategic intelligence community, drove early UAS development with the Cold War serving as a focusing element. Consequently, many UAS developed by airmen of the USAF and the US intelligence community pushed technological envelopes and focused on strategic ISR missions. However, operational needs

[7] US Joint Forces Command, *Joint Concept of Operations for Unmanned Aircraft Systems* (Norfolk, VA: November 2008), II-5 – II-7.

[8] US Joint Chiefs of Staff, Joint Publication 5-0, *Joint Operation Planning* (Washington, D.C.: 11 August 2011), III-1.

[9] US Air Force, Air Force Doctrine Document 2, *Operations and Organization* (Washington, D.C.: 3 April 2007), 8; US Army, Army Doctrine Publication 3-0, *Unified Land Operations* (Washington, D.C.: October 2011), 9.

during the Vietnam War, Operation DESERT STORM, OEF, and OIF, shifted the focus of UAS operations towards fulfilling tactical ISR needs, and lethal strike missions. The drive to develop sophisticated UAS results in qualities like extreme persistence. Additionally, combining ISR and lethal strike capabilities into one aircraft can result in a quicker operational tempo. However, sophisticated aircraft are expensive, even when those aircraft are unmanned. Also, technological advances do not always mature at expected rates. At times UAS help commanders speed up their operational tempo and extend their reach. However, airmen tend to push the limits of technology, which comes with a certain degree of risk.

History

During the initial stages of the Cold War, neither the United States Air Force (USAF), nor the United States Navy (USN) led UAS development from the standpoint of the air component. Between 1960 and 2000, the US intelligence community made the single greatest contribution to UAS development, funding more than forty percent of the overall investment made by the US government. This amounted to more than twice that of the next greatest contributor. Three agencies dominated this UAS development effort; the Central Intelligence Agency (CIA), the National Reconnaissance Office (NRO), and the USAF.[10]

UAS development was a risk that no service could afford to undertake on its own. The NRO had access to substantial financial resources, alleviating the risk of research and development. In return, the USAF provided the expertise in aerial weapon system innovation and development. While this relationship was necessary to advance UAS development during this time, it was not without its drawbacks. First, during the early 1960s, there was political fallout after Francis Powers, and the U-2 he was flying, was shot down over the Soviet Union. This incident highlighted a problem that the intelligence community tried to address with unmanned

[10] Ehrhard, 5.

aircraft; reducing the political risk associated with ISR missions. Second, this focus on strategic risk mitigation by the intelligence community drove UAS development in a way that was not always conducive to the operational needs of the military. By the 1970s, these competing interests became a significant hurdle in UAS development. Nevertheless, these early years were not without some operational success.[11]

The Vietnam War provided the first opportunity for operational commanders to use reconnaissance UAVs in combat operations. In August 1964, the USAF's Strategic Air Command (SAC) deployed the Ryan model 147 Lightning Bug to Kadena Air Base, Japan. Its mission was to gather information about Chinese air defenses and nuclear weapons programs.[12] On 15 November 1964, the Chinese shot down a Lightning Bug, but unlike the Powers' incident, it did not create a political controversy.[13] This operation proved invaluable as it established the precedence that unmanned aircraft demonstrated the ability to monitor Chinese military operations without creating an international incident.

The Lighting Bug was not just a success for the strategic intelligence community, but for the USAF and military as a whole. Between 1964 and 1975, Lighting Bugs flew 3,435 tactical reconnaissance sorties over North Vietnam.[14] Although it was originally designed as a high altitude platform (greater than 50,000 feet), by 1969 Lightning Bugs started flying at low level. Weather often prevented the effectiveness of medium and high altitude photoreconnaissance. Additionally, the USAF used the Lightning Bug extensively in high threat environments, and

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[11] Ehrhard, 4-5.

[12] William Wagner, *Lightning Bugs and Other Reconnaissance Drones* (Fallbrook, CA: Aero Publishers, 1982), 53, 56-57.

[13] Jack Raymond, "Pilotless Planers-Are They Effective Spies?" *New York Times*, 22 November 1964, sec. IV, p. 10E.

[14] Laurence R. Newcome, *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles* (Reston, VA: American Institute of Aeronautics and Astronautics, 2004), 83.

provided important battle damage assessment and electronic intelligence about North Vietnamese weapon systems.[15]

Lighting Bug employment during Vietnam highlighted several issues relevant to modern UAS operations. First, operational needs accelerated the employment of Lighting Bugs in Southeast Asia. Because of that accelerated timeline, contractors provided the necessary expertise to work through issues that the services would address normally during system development. However, contractors were not able to achieve operational success alone. It took professional airmen, in conjunction with contractors, to streamline Lightning Bug operations to the point where it became of dependable aircraft.[16] Two, the experience provided an operational template for UAS employment. Lighting Bugs were launched from air, land, and sea, conducted ISR missions consisting of photographic, infrared, and radar reconnaissance, as well as collecting electronic signals, and provided targeting information for lethal strikes.[17] Third, it demonstrated the flexible nature of UAS. The Lightning Bug was a high altitude strategic reconnaissance platform that was successfully adapted and employed in a low altitude tactical reconnaissance role. Fourth, it exposed the potential for tension between a force provider and an operational commander. SAC owned the Lighting Bugs, and managed their operations through the Strategic Reconnaissance Office located at Offutt AFB, Nebraska. Lightning Bug sorties were flown in support of 7th AF in Vietnam. While SAC attempted to streamline its process to meet the needs of the operational commander, the 7th AF commander, General John W. Vogt Jr., remained critical of the unresponsive nature of UAS operations. He believed that he needed operational control of these UAVs to maximize their use and the effects that they generated.[18]

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[15] Wagner, 93-94, 100-102.

[16] Wagner, 58-61.

[17] Newcome, 83-86.

[18] Paul W. Elder, *Buffalo Hunter 1970-1972*, Project CHECO Report (San Francisco, CA: Headquarters PACAF, 24 July 1973), 36.

As the Vietnam War began to wind down in the early 1970s, there was a lot of excitement over UAS potential. The confluence of three external factors was responsible for this enthusiasm. The first, and most important, was the rise of the Soviet air defense threat. Hundreds of American aviators became prisoners of war (POW) during attacks on North Vietnam because of an integrated multi-layered air defense system that utilized Soviet technology. Additionally, the Yom Kippur War of 1973 demonstrated the capabilities of Soviet air defense technology, even when operated by a second rate military force. That war led some to believe that modern air defenses rendered manned tactical aircraft obsolete.[19] Second, the combination of reduced military budgets post-Vietnam and the rising cost of traditional aircraft made UAVs look like an attractive low cost alternative. Third, technological advances in circuit boards and microprocessors led to an order of magnitude increase in computing power with a significant reduction in weight. The Secretary of the Air Force believed that UAVs possessed the potential to minimize manned aircraft attrition, conduct politically sensitive missions, and cost significantly less than the manned aircraft of the time. The political environment favored UAS expansion.[20]

In light of this changing strategic environment, several shifts occurred within the balance of organizations that developed UAS. By 1972, the USAF directed fourteen of sixteen major RPV programs and funded twenty-three of twenty-nine speculative RPV technology development programs. By 1974 the NRO stopped funding UAS development altogether.[21] Next, the drawdown in Vietnam allowed UAS development to focus on military operations in Europe. This environment was more tactically demanding than Vietnam. Consequently, the USAF's Tactical

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[19] Robert Frank Futrell, *Ideas, Concepts, Doctrine Vol. II* (Maxwell AFB, AL: Air University Press, 1989), 485.

[20] Ehrhard, 29.

[21] Ehrhard, 30-31.

Air Command (TAC) gained control of UAS development from SAC in 1976, and led development throughout that decade.[22]

The USAF had three UAS programs of interest during the 1970s, all designed to address the challenges identified within the European battlefield. The first program, Compass Dwell, was an extension of previous high altitude, long endurance UAV programs designed for combat support missions like reconnaissance and communications. This program utilized proven Schweizer sailplane designs, and conventional launch and recovery via a runway to keep development and operating costs low.[23] Compass Dwell was an economic success and met some performance goals. However, it ultimately failed to meet altitude and endurance requirements, so the USAF canceled Compass Dwell to focus on the second program of note during the 1970s.[24]

Compass Cope, was the next step in the high altitude, long endurance combat support UAS. It sought to overcome the performance limitations of Compass Dwell through more expensive technological advances, thus driving up the development costs. Additionally, European airspace regulations hampered operations as they prevented unmanned systems from flying in civilian airspace. Because of these constraints, the USAF ultimately turned to a modified U-2 to meet its immediate operational needs. While the U-2 lacked the endurance of Compass Dwell and Compass Cope, it was more cost effective to operate, and could fly higher and carry a bigger payload.[25]

The final program of the 1970s was a modified Lightning Bug designed for strike and tactical reconnaissance missions in high threat environments. The program advanced the legacy Lightning Bug into a true multi-mission platform, but failed to address the cost prohibitive operations and maintenance cost associated with the Lightning Bug's unconventional launch and

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[22] Wagner, 104.

[23] Newcome, 101-102.

[24] Ehrhard, 32.

[25] Ehrhard, 33-34.

recovery system. The projected annual operating cost of a single Lightning Bug unit, capable of generating eighteen sorties a day, was $35.3 million a year. Conversely, the combined operating cost of one F-4E wing (seventy-two aircraft) and one A-10 wing (seventy-two aircraft), capable of generating hundreds of sorties a day, was $41 million a year. By December 1977, a joint USAF/US Army study on US reconnaissance recommended that the USAF cancel the multi-mission Lightning Bug due to its high costs and limited operational capability.[26]

By 1979, the USAF took a step back from UAS development, as evident by the seventy percent reduction in the UAS budget. Cost overruns plagued every UAS program of the decade, contradicting the widely held belief that UAS were a more affordable than manned systems. Additionally, UAVs failed to meet the operational needs of the European theater. While expensive, UAS proved acceptable for limited intensity conflict, but failed to demonstrate meaningful value for the major focus of USAF plans in the 1970s.[27]

During this same time, other manned aircraft developments offset the lackluster performance of unmanned systems. The stealth fighter successfully demonstrated its low observable technology and went into full-scale development.[28] The combination of stealth technology, and advances in precision-guided standoff munitions addressed the challenge of attacking heavily defended targets. Tactical reconnaissance did suffer, but advances in the form of sensors for manned platforms offset some of this deficiency. Finally, advances in electronic attack aircraft and pods negated the need for UAS in an electronic combat role. Consequently, the USAF entered the 1980s with UAS on hiatus.[29]

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[26] Ehrhard, 34-36.

[27] Ehrhard, 36, 38.

[28] David C. Aronstein and Albert C. Piccirillo, *Have Blue and the F-117A* (Reston, VA: American Institute of Aeronautics and Astronautics, 1998), 58.

[29] Ehrhard, 38-40.

Just as the USAF stepped away from UAS development, the NRO started development of one of the most ambitious, expensive, and highly classified UAS programs to date. The Advanced Airborne Reconnaissance System (AARS) program began in the early 1980s during the Cold War defense buildup. The NRO identified it as a potential replacement for the SR-71 and U-2. However, neither the SR-71 nor the U-2 had the necessary capabilities to meet the reconnaissance collection requirements presented by mobile surface-to-surface missiles, developed by the Soviet Union in the late 1970s. The national intelligence community needed a high altitude, high endurance system capable of accomplishing persistent reconnaissance in contested/denied Soviet airspace while providing real-time imagery. AARS pushed the technological envelope, which made integration of its various components a challenge. Additionally, the technologies were so secret, and the cost of the aircraft and payload was so high that losing AARS over enemy territory became unthinkable. The combination of the Soviet Union's collapse, the program's high cost, and the lack of strong USAF backing led to the cancellation of AARS in 1992.[30]

When the USAF resumed UAS development in the mid to late-1980s, it did so under a congressionally mandated joint approach. From 1986 to 1988, the House and Senate Armed Services Committees and the Senate Appropriations Committee questioned the effectiveness of individual services developing UAS programs separately. In 1988 Congress transferred individual service UAS funds to the Department of Defense's (DOD) newly established joint RPV program office, and tasked that office with eliminating excessive cost in various DOD UAV programs.[31] The Joint Program Office (JPO) led joint UAS development efforts until 1993 when the DOD consolidated its reconnaissance programs under the Defense Airborne Reconnaissance Office (DARO). The UAS JPO dissolved shortly after DARO's establishment, so DARO led joint UAS development efforts until 1998. By that time, DARO proved to be ineffective at managing a joint

[30] Ehrhard, 13-17.

[31] General Accounting Office, *Assessment of DOD's Unmanned Aerial Vehicle Master Plan* (Washington, D.C.: 9 December 1988), 1-14.

UAS development process.[32] The ten years of joint UAS development was not very successful in terms of fielding systems, however several important developments occurred during this time.

The DOD published the first Master Plan for UAV Development in 1988, which outlined the types of UAVs required by each service, mission capabilities, and the manner in which the services would increase interoperability and reduce overlap. The report identified six major mission types including Reconnaissance, Surveillance, and Target Acquisition (RSTA), targeting spotting, Command and Control (C2), meteorological collection, Nuclear Chemical and Biological (NBC) detection, and disruption and deception. The USAF viewed the use of UAS as complementary to manned aircraft, and emphasized its need for platforms that performed RSTA (including bombing damage assessment), C2, meteorological data collection, and NBC detection.[33] Prior to this report, the USAF began a joint UAS program that sought to address some of those needs.

The JPO inherited a joint USAF/USN medium range, tactical reconnaissance UAV program that began in early 1985. The USN had the lead for airframe development, while the USAF took responsibility for the sensor suite and data link. By late 1993, this joint approached failed due to the incompatibility of USAF and USN requirements. Even though it never reached operational capability, the medium range UAV program demonstrated the potential to meet a capability gap in tactical reconnaissance that Operation DESERT STORM highlighted.[34] During that conflict, the USAF employed twenty-four RF-4C tactical reconnaissance fighters, many of which did not arrive in theater until February 1991. Coalition partners added an additional sixteen

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[32] Ehrhard, 47, 49.

[33] Department of Defense, *DOD Joint UAV Program Master Plan* (Washington, D.C.: 26 July 1988), 10-23.

[34] Ehrhard, 41-42.

reconnaissance fighters, but the combined capacity was still insufficient. By the end of the first Gulf War, the USAF firmly established its desire for a tactical reconnaissance aircraft.[35]

Several technological innovations occurred during the late 1980s/early 1990s that helped UAS development. Global Position System (GPS) revolutionized navigation. Microprocessor advances increased computing power, allowing aircraft to carry more capable payloads with higher bandwidth data links that were less vulnerable to electronic attack.[36] Arguably, the Predator UAS benefitted more from these technological advances more than any other program of the early 1990s.

While Operation DESERT STORM highlighted the military's need for a tactical reconnaissance aircraft, the Bosnian conflict of 1992 created the motivation to address the problem. Initial pressure for Predator development came from the Chairman and Vice Chairman of the Joint Chiefs of Staff who pushed for the development of a persistent reconnaissance capability. The Pentagon acquisitions office established the requirements, and development ensued. It is interesting to note that initial Predator development occurred with almost no service input. Eventually the Army took on a leading role in the development of a derivative of the Gnat-750.[37] The CIA employed the Gnat-750 in Bosnia in 1993 and accomplished bombing damage assessment and convoy tracking. In doing so, it successfully demonstrated the operational potential of a medium altitude, high endurance, ISR UAS.[38] Predator's first flight test occurred in July 1994, and by the spring of 1995, it participated in the annual Roving-Sands joint training

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[35] Thomas A. Keaney and Eliot A. Cohen, *Revolution in Warfare? Air Power in the Persian Gulf* (Annapolis, MD: Naval Institute Press, 1995), 163-164.

[36] Ehrhard, 47.

[37] Ehrhard, 49-50.

[38] Blom, 93-94.

exercise.[39] Predator's initial success at Roving-Sands led to its first operational deployment to Bosnia from July to November 1995.

Throughout the summer and fall of 1995, the Army successfully employed the Predator in a variety of ISR roles.[40] Specifically, Predator proved instrumental in verifying compliance with arms control agreements. However, the Predator lacked all weather capability and eventually, the constant cloud cover and in-flight icing precluded effective Predator flight operations. Nevertheless, this experience led to several upgrades including a synthetic aperture radar and a de-icing system that gave Predator some all-weather capability. Additionally, Predator received a satellite communications data-link system, capable of transmitting real-time imagery via the Joint Broadcast System. This enabled multiple users to view the feed simultaneously.[41] The Predator established its place in the military force structure through successful operations in Bosnia.

Before the Army employed Predator in Bosnia, the USAF signaled its desire to gain control of the program by establishing the first Predator squadron (11th Reconnaissance Squadron) in August 1995. At the time, the Chief of Staff of the Air Force, General Ronald R. Fogleman, provided three reasons to do this. First, he recognized that due to its success, the DOD would field Predator. He wanted to the USAF to control it as the Predator was a theater capable aircraft that operated in the Air Component Commander's airspace. Second, at the time Army operators at Fort Huachuca were crashing Hunter UAVs at an alarming rate. Fogleman was concerned about these same operators controlling the larger and more advanced Predator. Finally, Fogleman saw himself as an agent of change, capable of incorporating a non-standard solution in

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[39] Yenne, 59.

[40] Michael R. Thirtle, Robert V. Johnson, and John L. Birkler, *The Predator ACTD* (Santa Monica, CA: RAND, 1997), 8-9.

[41] Department of Defense, *UAV Annual Report, FY 1996* (Washington, D.C.: 6 November 1996), 7-8.

a transformational way. Ultimately, Fogleman gained control of the Predator program by promising the Army Chief of Staff that the USAF would remain responsive to Army battlefield reconnaissance requirements. With this agreement, the Army not only ceded control of the Predator to the USAF, it also relinquished the substantial resources associated with establishing the necessary sustainment infrastructure that transforms a developing platform into an operational system.[42]

In 1999, the USAF employed the Predator during Operation ALLIED FORCE (OAF). Continued upgrades to the UAS allowed it to perform as a signals intelligence collection platform (collecting against cell phones, portable radios, and other voice technologies) in addition to its traditional ISR role. The Predator also marked targets for the first time in combat using a laser designator.[43] Up to this point, the services had allowed tactical reconnaissance capabilities to atrophy. During the 1990s, the Predator came out of nowhere and addressed a capabilities need for operational commanders.[44]

The High Altitude Endurance (HAE) UAS project of the 1990s was the other program of note from an airmen's perspective. This program was an offshoot of the high altitude long endurance program of the 1970s and developed two UAS that sought to address similar operational needs. The DarkStar resembled a substantially scaled down version of AARS, and sought to perform a similar mission of persistent reconnaissance in contested airspace.[45] DarkStar experienced several problems throughout initial testing and crashed during takeoff on its second

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[42] Ehrhard, 50-51.

[43] Benjamin S. Lambeth, *NATO's Air War for Kosovo: A Strategic and Operational Assessment* (Washington, D.C.: RAND, 2001), 94-97.

[44] Ehrhard, 52.

[45] *UAV Annual Report, FY 1996*, 22.

test flight on 22 April 1996.[46] Cost over-runs, flight test problems, and the lack of service support led to DarkStar's cancellation in January 1999.[47]

Global Hawk was the second, and more successful, HAE program. It was similar to DarkStar, but optimized for low to moderate threat environments.[48] Its first flight occurred in February 1998, and by July 2001 Beale AFB began preparations for Global Hawk's operational bed down.[49] The HAE UAS program was the last significant UAS development effort prior to OEF and OIF.

Contemporary Operations

Throughout the 1990s, UAS demonstrated their operational utility. During OEF and OIF, UAS proved to be indispensable. In particular, UAS continued to function in their historic role as ISR/RSTA platforms, supporting commanders through non-lethal means. However, OEF and OIF demonstrated an increase in UAS capability and a shift towards lethal multi-mission systems that retained traditional ISR and RSTA functions. Consequently, increasingly sophisticated reconnaissance, targeting, and weapons delivery technology allowed UAS to not only shorten the kill chain, but also complete it themselves.[50]

Lightning Bug operations during the Vietnam War demonstrated how commanders use UAS for high-risk reconnaissance missions. Operations in Afghanistan and Iraq continued to demonstrate this utility. During the initial stages of OIF, commanders sent several Predators into the Baghdad air defense network to assess Iraqi engagement tactics. Surprisingly, most of these aircraft survived the mission. However, one of the Predators crashed in the Tigris River in the

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[46] Yenne, 72-73.

[47] Ehrhard, 54.

[48] *UAV Annual Report, FY 1996*, 20.

[49] Yenne, 76.

[50] Department of Defense, *Unmanned Systems Roadmap; FY 2009-2034* (Washington, D.C.: 20 April 2009), xiii.

heart of Baghdad, and Iraqi television recorded the frantic search for a pilot. Obviously, they never found the pilot because he was 200 miles away at his control station.[51]

As both OEF and OIF transitioned from major combat operations, to counter-insurgency and stability operations, air forces played an increasingly vital role in intelligence operations.[52] Indeed, lethal airstrikes, no matter how precise, can have unintended consequences and produce a negative effect.[53] Because of this, the persistent ISR/RSTA capabilities of UAS became indispensable to commanders, as demonstrated by the 660 percent increase in Predator and Reaper Combat Air Patrols (CAP) from 2004 to 2009.[54] In addition to Predator and Reaper, the RQ-4 Global Hawk made substantial contributions in Afghanistan and Iraq by providing wide area reconnaissance and surveillance. In March 2003, Global Hawk played an instrumental role in identifying and tracking the Iraqi Medina division during a sandstorm. The intelligence provided by Global Hawk led to the destruction of that division before it could engage coalition ground forces.[55] Additionally, unlike many manned platforms, the minimal noise signature and/or high altitude of most UAS employed by airmen allowed operations to go undetected.[56] Finally, the development of a Remotely Operated Video Enhanced Receiver (ROVER) during the early stages of OEF, allowed ground forces in the field to see live FMV Predator feeds for the first time.[57] Subsequently, the desire for ROVER became so overwhelming that advanced targeting pods used by manned aircraft, in addition to UAS, were equipped with the system. UAS like Predator,

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[51] Yenne, 96.

[52] US Joint Chiefs of Staff, Joint Publication 3-24, *Counter Insurgency Operations* (Washington, D.C.: 5 October 2009), 7-4.

[53] Mark A. Clodfelter, "Back from the Future: The Impact of Change on Airpower in the Decades Ahead," *Strategic Studies Quarterly* 3, Fall 2009, 111.

[54] US Air Force, "United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047," (briefing slides, associated with *United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047)* (Washington, D.C.: 18 May 2009), slide 5.

[55] Yenne, 99.

[56] "United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047," slide 4.

[57] Richard Whittle, *Predator's Big Safari* (Mitchell Institute, August 2011), 28.

Reaper, and Global Hawk were so successful as persistent ISR/RSTA platforms, that the demand for their support by commanders at all levels greatly exceeded the capacity that existed.[58]

While UAS continued to perform well in traditional ISR roles, airmen pushed development and expanded UAS capabilities beyond traditional ISR and RSTA missions. In 1999, Operation ALLIED FORCE demonstrated that a UAS could successfully operate as a forward airborne controller, marking targets and directing other manned aircraft to strike them. During OEF and OIF, commanders continued to employ the Predator in this fashion, reducing target acquisition time for aircraft like the AC-130. UAS became the key ingredient to reducing sensor-to-shooter time, resulting in operations that were more efficient.[59] Furthermore, in the wake of OAF, the USAF added a lethal capability to the Predator, and changed the culture that surrounded UAS.[60] On the first night of OEF, General Franks ordered the first Hellfire strike by a Predator in combat.[61] Predator now combined a persistent ISR aircraft with a lethal strike capability that allowed commanders to engage targets that might otherwise get away.[62] This ability has had lasting effects on US national security and foreign policy.[63]

Arguably, one of the most publicized aspects of OEF is the high value target (HVT) anti-terrorism campaign executed by UAS in Pakistan's Federally Administered Tribal Area (FATA). Pakistan is unable to maintain effective control and governance in this area, and International Security Assistance Force (ISAF) ground forces cannot conduct operations in this area as it is in Pakistan. Thus, it provides a potential safe haven for many terrorist organizations and leaders. UAS provide an alternative means of engagement. During the first ten months of 2008, there

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[58] Jeffrey Kappenman, "Army Unmanned Aircraft Systems: Decisive in Battle," *Joint Force Quarterly* 49, April 2008, 20.

[59] Yenne, 87.

[60] Whittle, 17.

[61] Whittle, 8.

[62] Yenne, 87.

[63] Whittle, 9.

were twenty-three HVT strikes in Pakistan.[64] This campaign continues today, and while it may not be robust, "it forces terrorists to act defensively and devote a disparate amount of their time and energy to survival instead of planning and executing attacks."[65] While it may be difficult to measure the overall effectiveness of this campaign, it does extend the operational reach of US forces, and allows commanders to take initiative where they have not been able to in the past.

From an airmen's perspective, UAS operations in Afghanistan and Iraq have reinforced several historical strengths, demonstrated new capabilities, and revealed some weaknesses. Flight endurance beyond human limits has always been an appealing UAS capability, but "[s]tability operations in Iraq and Afghanistan have seen persistence eclipse sortie generation as a metric."[66] Additionally, UAS reduce risk to forces, allowing commanders to send unmanned platforms into dangerous environments. While that is not new, the advent of remote split operations (RSO) further reduces risk by decreasing the number of forward deployed personnel. Finally, multi-mission UAS that integrate persistent ISR with lethal strike capabilities emerged, giving commanders the ability to find, fix, and engage targets at a more rapid pace.[67] However, these remarkable advances came with some challenges as well.

The rapid rise in the number of UAS revealed limits in radio bandwidth. Second, the demand for persistent ISR support outweighs capacity, leading to tension among commanders especially at lower levels. The shortage is not just a matter of building more aircraft, as there is also a chronic shortage in UAS pilots.[68] Lastly, some commanders get so reliant on a live FMV feed that they are unable to make decisions without it.[69] Consequently, instead of enabling

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[64] Blom, 115.

[65] Peter M. Cullen, "The Role of Targeted Killing in the Campaign against Terror," *Joint Force Quarterly* 48, January 2008, 26.

[66] Rebecca Grant, "Expeditionary Fighter," *Air Force Magazine,* March 2005, *42.*

[67] "United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047," Slide 4.

[68] Blom, 119.

[69] Blom, 121.

information superiority, UAS (or the lack thereof) potentially increases operational friction. This final theme is arguably the most substantial, and relevant to commanders of all domains. Therefore, it is subsequently covered in more detail.

Future Vision

The DOD recently published military guidance that signals a strategic pivot toward the Asia-Pacific region. This guidance identifies projecting power despite Anti-Access/Area Denial (A2/AD) challenges as one of the primary missions of the US military.[70] Additionally, the DOD published a Joint Operational Access Concept that expands on the necessary requirements to conduct military operations in an A2/AD environment. Key capabilities include long-range reconnaissance and surveillance systems capable of operating in high threat areas for extended durations. UAS are a key capability as they can loiter and provide intelligence collection or fires in an objective area. [71] As airmen develop future UAS, this guidance will shape their efforts.

In an effort to improve interoperability and reduce duplication of effort, the DOD provides joint guidance on future unmanned systems development. Within the broader joint capabilities areas, future UAS have significant potential to improve battle space awareness, force application, protection, and logistics.[72] In order to do that, UAS must be faster, more maneuverable, and stealthy with larger payloads, longer endurance, and the ability to sense and avoid obstacles.[73] In addition to defining these capability and performance requirements, the DOD guidance standardizes UAS categorization. While UAS organization based on echelon of command, effects, and capability are still useful, the DOD roadmap provides an overarching five

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[70] Department of Defense, *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (Washington, D.C.: January 2012), 4-5.

[71] Department of Defense, *Joint Operational Access Concept (JOACC)* (Washington, D.C.: January 2012), 9-10.

[72] *Unmanned Systems Roadmap; FY 2009-2034*, 8-12.

[73] *Unmanned Systems Roadmap; FY 2009-2034*, 30.

group system. UAS development by airmen tends to focus on the fourth and fifth groups (medium to large aircraft).

The USAF vision for UAS development consists of four major themes. First, UAS are viable alternatives to a range of traditionally manned missions. Second, UAS harness increasingly automated, modular, and sustainable systems resulting in a leaner, more adaptable force that maximizes capabilities. Third, develop UAS using an integrated approach with other services, coalition partners, academia, and industry, and takes advantage of the persistence, flexibility, and efficiency that UAS provide. Finally, the goal is to maximize UAS development to increase joint warfighting capability while promoting service interdependency and wise use of tax dollars.[74]

Within the next three to five years, several material and organizational changes will work toward this vision. First, the USAF is going to phase out the Predator, and standardize its Group 4 UAS fleet with the MQ-9 Reaper. In addition to providing roughly twice the performance capability as Predator, Reaper is also capable of employing a new Wide Area Airborne Surveillance (WAAS) pod. Instead of the traditional ability to observe a single target, with one ROVER feed, WAAS provides a sixty-four square kilometer coverage area with up to thirty ROVER feeds. "MQ-9, with nearly twice the performance of the MQ-1 and nearly ten times the external payload— matched up with Wide Area Airborne Surveillance system, will deliver thirteen to eventually sixty times more capability than MQ-1 series UAS."[75] Second, the USAF is making several organizational and training changes to address the shortage of qualified operators and maintainers. Instead of using specialized undergraduate pilot training to develop UAS pilots, the USAF is exploring the possibility of creating a new non-traditional pilot training program and career field. The USAF is also looking at using military maintenance, instead of contractors, for

[74] US Air Force, *United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047* (Washington, D.C.: 18 May 2009), 15.

[75] *USAF UAS Flightplan: 2009-2047*, 37-38.

UAS operations. This has the potential to be cheaper and more responsive in the long run. Finally, the USAF is trying to standardize training for UAS mission intelligence coordinators.[76]

Looking out five to ten years, UAS development becomes more advanced. As technologies improve, the idea of autonomous UAS operations becomes more practical. Currently, with one pilot flying one aircraft, it takes ten pilots to operate a single Reaper CAP. Mulit-Aircraft Control (MAC) allows one pilot to control two Reaper CAPs with a third aircraft in transit, while retaining the ability to surge with one more aircraft. This reduces the pilot requirements by fifty percent. The second arm of future UAS development is modularity. The USAF will develop standardized medium and large UAS airframes that are reconfigurable based on mission needs. In addition to being modular, both platforms incorporate enhanced autonomy and stealth technology. The medium system will take on many of the missions currently performed by current manned fighters while retaining the persistent ISR capability of Predators and Reapers. The large system will perform many of the traditional tanker and transport aircraft missions, while retaining the persistent ISR capability of Global Hawk. Eventually, the large system will accomplish strategic attack and global strike missions as well. However, the USAF does not expect that capability to exist until after 2030.[77]

UAS development by airmen attempts to leverage several strengths, and account for existing limitations in order to meet potential A2/AD challenges of the near future. As demonstrated by operations in Afghanistan and Iraq, UAS have redefined persistence in the air domain. Current visions look to expand this capability, extending the endurance of aircraft from hours to days and weeks.[78] Likewise, the same performance improvements that lead to extended endurance also translate into longer range. Future UAS development also attempts to reduce

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[76] *USAF UAS Flightplan: 2009-2047*, 28-30.

[77] *USAF UAS Flightplan: 2009-2047*, 39-40.

[78] *Unmanned Systems Roadmap; FY 2009-2034*, 8.

operational risk to both the force and the mission. The extended range of future systems reduces the need for forward bases, while eliminating the risk to aircrew in an A2/AD environment. Additionally, the combination of stealth and persistence, with the integration of sensor and shooter in one platform allows future systems to accomplish the find, fix, and finish targeting cycle independently.[79]

Simultaneously, UAS development attempts to address several limitations. OEF and OIF demonstrated that the USAF does not have enough UAS operators. Changes in training and career management, along with advances in autonomous operations attempts to address this. Additionally, current UAS operations are constrained by US and international airspace regulations. The military is working with the Federal Aviation Administration (FAA), who establishes international standards, to address this. The same sense and avoid technology that will help future UAS avoid terrain or surface to air missiles might eventually meet safety regulation requirements, allowing UAS to cohabitate airspace with civilian aircraft.[80] Finally, many of these solutions are heavily dependent on technological advances. The historical development of UAS demonstrates that technological advances do not always mature at the expected rate, and can often prevent the operationalization of a UAS.

Significance to Operational Art

The historical context of UAS development and operations by airmen reveal several key points. First, there is often a false assumption that UAS are cheaper than their manned counter-parts. Historically, UAS costs are comparable to manned aircraft of similar sophistication. Cost comparisons are inherently problematic, however general trends emerge that are useful. A comparison of manned and unmanned programs using similar acquisition and development

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[79]"United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047," slide 4.

[80] *Unmanned Systems Roadmap; FY 2009-2034*, 91-101.

processes is revealing. The Have Blue/F-117 technology demonstration program cost $170 million (FY 94 dollars). Similar development of the Global Hawk technology demonstrator cost $250 million (FY 94 – FY 98 dollars).[81] Operations costs are also comparable. A modified Lightning Bug unit of the 1970s, capable of producing eighteen sorties a day had a similar annual operating cost of two tactical fighter wings capable of generating hundreds of sorties a day. Finally, the AARS program of the 1980s was so technologically advanced that a combat loss over enemy territory was unthinkable. It was also so expensive that the USAF cancelled it in 1992. From this, it is possible to infer that UAS, as airmen have pursued them, do not have any effect on the low-density nature of airpower, and that current operational approaches used to employ airpower will remain consistent with the employment of UAS.[82]

Second, the historical context of UAS operations and development by airmen demonstrate the role that professional airmen play in making UAS operations successful. Lightning Bug operations during Vietnam demonstrate this. Sortie generation rates were too low to make the Lightning Bug a viable operational tool until SAC airmen became involved. These airmen imposed aviation standards onto Lightning Bug maintenance, and support. They understood that UAS were not just sensor platforms, or some other tool; they were first and foremost an airplane. When airmen imposed aviation standards on UAS support and operations, it provided the best atmosphere for success.[83] This was significant, as it decreased the risk to the mission associated with premature culmination of UAS operations.

Finally, Lightning Bug operations during the Vietnam War exposed C2 challenges that affect current operations. During the Vietnam War, SAC had operational control of the Lightning

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[81] Jeffrey A. Drezner, Geoffrey Sommer, and Robert S. Leonard, *Innovative Management in the DARPA High Altitude Endurance Unmanned Aerial Vehicle Program: Phase II Experience* (Washington, D.C.: RAND, 1999), 116.

[82] Ehrhard, 35, 17.

[83] Ehrhard, 45.

Bug units that flew missions for the 7th AF commander. As the supported command, 7th AF felt that SAC was not responsive enough to operational needs.[84] Current joint doctrine for command and control of air operations addresses this issue for airmen. The Joint Forces Air Component Commander normally has operational control over forces assigned and tactical control over forces made available for tasking.[85] The more relevant challenge for current operations exists in the supporting and supported relationship between functional component commanders. Again, joint doctrine for command and control of air operations effectively addresses this challenge, as it makes no distinction between manned and unmanned aircraft for allocation and apportionment of air assets.[86] The USAF vision for UAS development reveals that airmen are comfortable with this lack of distinction between manned and unmanned systems. However, as subsequent sections of this monograph reveal, military professionals from the land and sea domains are not as likely to share a similar view. Airmen need to remain aware of these perspectives, and sensitive to the needs of other functional components, especially when operating in a supporting role. The tension that arises from the low-density/high-demand nature of air power is not new. Continuing to work through these tensions is critical to sequencing joint military operations in time, space, and purpose.

Contemporary UAS operations by airmen reveal two points of note. First, OEF and OIF demonstrate a shift towards multi-mission platforms that shrink the sensor to effects gap by combining lethal strike and persistent ISR capabilities into one aircraft.[87] Second, this shift signals a transition from using UAS as force support platforms, to force projection weapons. HVT strikes in places like Pakistan and Yemen demonstrate this trend. Based on historical precedence,

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[84] Elder, 36.

[85] US Joint Chiefs of Staff, Joint Publication 3-30, *Command and Control for Joint Air Operations* (Washington, D.C.: 12 January 2010), II-2.

[86] *Joint Concept of Operations for Unmanned Aircraft Systems*, III-10-III-11.

[87] Yenne, 87.

UAS operate in places and in ways that are not feasible for manned aircraft.[88] By shrinking the the between target acquisition and target engagement, and by operating UAS in areas that are normally off limits to manned aircraft, operational commanders are able to increase the tempo of friendly operations, relative to the enemy, while expanding operational reach. This creates an opportunity for commanders to seize or retain the initiative.

The future vision of UAS development by airmen acknowledges the expansion of UAS capabilities, attempting to leverage associated opportunities, while negating the challenges that arise from this growth. With UAS, airmen see an opportunity to reduce the risk to the force by reducing the exposure of aircrew to potential A2/AD environments as well minimizing the footprint of forward bases.[89] However, there is currently a shortage of UAS operators across the military that will likely get worse until actively addressed. The USAF, in particular, addresses this challenge by looking at changes in doctrine, organization, training, and by leveraging emerging technological solutions.[90] In addition to reducing risk to forces, this approach attempts to reduce the risk to mission by minimizing the operator shortfall.

Addressing the organizational challenges surrounding UAS expansion is critical to leveraging unique UAS potential. Extreme persistence is arguably a unique UAS capability that has the potential to re-define the nature of air power. The USAF's capstone doctrine publication, Air Force Doctrine Document (AFDD) 1, attempts to capture the nature of air power through seven tenets that complement the nine principles of war.[91] Persistence is one of these seven tenets. The 2003 version of AFDD 1 defined the persistent nature of air and space power as *unique* [emphasis added]. Exceptional speed, range, and flexibility allow airmen to "visit and revisit a

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[88] Raymond, sec. IV, p. 10E.

[89] "United States Air Force Unmanned Aircraft Systems Flight Plan: 2009-2047," slide 4.

[90] *USAF UAS Flightplan: 2009-2047*, 28-30.

[91] AFDD 1 (2011), 37.

wide range of targets nearly at will."[92] The 2011 version of AFDD 1 offers a very similar definition of persistence. However, it omitted the word unique.[93] This subtle change marks a potential transition to a more traditional definition of the word persistence that emphasizes existence or endurance over a prolonged period. The extreme persistent potential of UAS to endure over long periods of time, combined with the speed, range, and flexibility that is historically associated with air power may very well transform the nature of air power; similar to the way precision guided munitions re-defined the way mass is associated with air operations.[94]

Land Component

The US Army and USMC are the primary contributors to UAS development and operations for land domain forces. As with manned aviation platforms, soldiers and marines view UAS as an enabler to support tactical maneuver and fires organizations. Tactical ISR operations by UAS in OEF and OIF have had a profound impact on how ground forces operate, aiding in a ground commander's ability to make decisions in a timely manner. Because of this, the desire for ISR UAS has highlighted C2 and interoperability issues that both the US Army and USMC are actively addressing. Additionally, the substantial amount of data generated by ISR UAS also demonstrates the negative impact that UAS can have on operational tempo. This concept is not unique to land component forces, but ground operations in Afghanistan and Iraq reveal both the positive and negative effect the UAS can have on operations.

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[92] US Air Force, Air Force Doctrine Document 1, *Air Force Basic Doctrine* (Washington, D.C.: 17 November 2003), 31.

[93] AFDD 1 (2011), 40.

[94] Blom, 114. Blom describes how the USAF, using precision guided munitions, struck a comparable number of targets on a daily bases in OEF as it did during Operation DESERT STORM, using 200 sorties a day instead of 3000.

History

During the 1950s and 1960s, the Army dominated UAS development for land component forces. One of the Army's first programs examined the feasibility of using small UAVs, similar in size to current Shadow UAVs, to lay communication wire on the battlefield. By the mid-1950s, the Army expanded UAS testing to include larger, medium altitude capable platforms designed to perform tactical reconnaissance. This program led to a series of four small drones (SD). SD-1 deployed to Germany in 1960 and utilized radar for beyond visual range control. Each SD aircraft that followed SD-1 became progressively larger and faster with more sophisticated sensor suites that expanded the UAVs capability. SD-4 was a jet powered, high altitude, nearly supersonic aircraft better suited for strategic reconnaissance.[95]

During the early years of the Cold War, the United States Marine Corps (USMC) had one UAS program of significance. The Bikini UAV was a small aircraft, similar in size and concept to the current Shadow. It was strictly a tactical reconnaissance platform, limited to thirty minutes of flight with in visual range of the operator. Prior to its cancellation in 1967, Bikini made a technological contribution to UAS development. In 1964, Bikini possessed the capability of transmitting its photographs from an airborne camera to a ground station. It took two minutes to display the initial photograph, and then an additional eight seconds for each subsequent transmission. The Bikini's transmission system was not ideal, as it only transmitted low-resolution photos. Ground crews still had to develop the pictures taken in flight upon recovery of the aircraft.[96] In spite of some initial success by the Army's SD program and the USMC Bikini, land forces did little to develop and employ UAS during the Vietnam War era.

After the Vietnam War, the Army had two major programs that continued developing low to medium altitude UAS for tactical reconnaissance. Sky Eye was the first program that

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[95] Blom, 49-51.

[96] Newcome, 75-76; Blom, 52.

encompassed eight different aircraft with a variety of capabilities. Sky Eye aircraft operations required a six-person crew for transportation, launch, recovery, and in flight control. Operators flew it manually, on autopilot, or from a pre-programmed flight plan, and it transmitted a real time video signal. It also had an interchangeable sensor suite, adjustable to specific mission needs. The Army had enough success with the Sky Eye program that the Royal Thai Air Force purchased a squadron of aircraft in 1982. Additionally, during the mid-1980s, the Army successfully deployed Sky Eye aircraft for operations in Central America. The Army's second program of this era overshadowed the success of Sky Eye.[97]

By the mid-1970s, the Army required a platform capable of designating targets for its Copperhead precision guided munitions. In 1975, Aquila went into development. Aquila was another small UAV, again similar to in size to Shadow, but its mission as a target designator was more sophisticated than traditional tactical reconnaissance. Data-link and sensor suite requirements led to significant cost over-runs. Aquila flew 105 test flights, failing to meet standards on all but seven. By 1985 Congress refused to fund production of Aquila because of developmental and performance problems. In 1987, the Army cancelled the program.[98]

Despite this setback, the US Army and USMC continued to develop UAS for their needs. In 1988, the DOD Master Plan for UAV Development described the operational capabilities necessary to support land forces. Both the US Army and the USMC viewed operational UAS needs in a direct support relationship to echelon of command. The US Army defined its requirements according to battalion, brigade, division, and corps echelons of command. Battalion commanders needed RSTA out to fifteen kilometers. Brigade commanders had a similar mission

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[97] Blom, 66-68.

[98] General Accounting Office, *Unmanned Aerial Vehicles: DOD's Acquisition Efforts* (Testimony Before the Subcommittees on Military Research and Development and Military Procurement, Committee on National Security, House of Representatives: Statement of Louis J. Rodrigues, Director, Defense Acquisitions Issues, National Security and International Affairs Division), GAO/T-NSIAD-97-138, April 1997, 1-2, 8.

need out to thirty kilometers. Division and corps commanders both needed some degree of all six major mission areas defined by the report for six to twelve hours at a time. Division commanders needed this capability out to ninety kilometers while Corps commanders needed it out to 300 kilometers. The USMC defined the need for a small ISR UAS, employed at the company or battalion level that provided real-time video. They also outlined the need for a larger system, employed by USMC task force commanders, which provided RSTA and C2 support.[99]

The JPO had several UAS programs in the late 1980s/early 1990s that sought to address these needs, but only one that deserves mention. The Short Range UAS program focused on developing a real-time ISR platform to serve Marine Air Ground Task Force (MAGTAF), and US Army Corps and higher command echelons. In 1992, the JPO selected the Hunter UAV for development. It had several problems during testing and fielding. Hunter's data link limited its range, forcing it to remain within line of sight. It had numerous aircraft control issues and several avionics malfunctions, which investigators linked to operator and maintenance error. By January 1996, DOD allowed the acquisition program to expire.[100] The Army had already acquired seven systems (multiple vehicles per systems) and later employed Hunter in Kosovo and Iraq, demonstrating some operational utility.[101]

Operation DESERT STORM ushered in a new era in UAS, as it was the first conflict in which all four services employed unmanned aircraft. Although the USN originally acquired the Pioneer UAS in the mid-1980s, the US Army used it for RSTA, while the USMC used Pioneer to direct artillery fires and close air support aircraft. Even though US Army and USMC units employed the system in a limited manner, Pioneer was an effective platform. However, issues existed. The most significant was the lack of interoperability. The USN, US Army, and USMC,

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[99] *DOD Joint UAV Master Plan,* 26 July 1988, 14-20. Blom 73-74.

[100] *Unmanned Aerial Vehicles: DOD's Acquisition Efforts*, 3-4, 9.

[101] Department of Defense Command and Control Research Program, *Lessons from Kosovo: The KFOR Experience*, Larry Wentz, ed. 2002, 457.

had different video formats, making it difficult to share footage.[102] Ultimately, the success of Pioneer in Operation DESERT STORM led to the acquisition of more systems and continued employment in the conflicts of the 1990s. The US Army successfully used it in support of operations in Somalia in 1993, while the Marines employed it during the 1995 Bosnian conflict.[103] Throughout the 1990s, small tactical UAS emerged as a viable system to support land operations.

Contemporary Operations

During OEF and OIF, UAS became an integral part of land component forces operations. The expansion of UAS throughout formations provided ground commanders at all levels with a better understanding of the battle space, and improved C2.[104] This improved battlefield situational awareness expedited the sensor to effects timeline while minimizing risk to ground forces.[105] However, while UAS are a combat multiplier for ground forces, their unique capabilities come with some challenges as well.

Throughout operations in Afghanistan and Iraq, soldiers and marines looked to employ UAS in direct support of tactical maneuver units at all levels. OEF and OIF represented the first major conflict in which UAS had advanced enough to do this, and from the outset, UAS were an integral part of planning and executing ground combat operations.[106] In general, land forces continued to employ UAS in traditional ISR/RSTA roles.

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[102] Department of Defense, *Conduct of the Persian Gulf War: Final Report to Congress* (April 1992), 395-396, 806-809.

[103] Blom, 94.

[104] Blom, 105.

[105] Association of the USArmy, *U.S. Army Aviation: Balancing Current and Future Demands* (Arlington, VA: Institute of Land Warfare, January 2008), 3-4.

[106] Yenne, 95.

Lower echelon units, battalion and below, regularly employed organic UAS like Raven, Dragon Eye, and eventually Scan Eagle. The US Army first used the hand launched Raven in 2002. It has a six nautical mile range, and small tactical units used it for ISR to see over the next hill or around the next corner. In 2006, the USMC adopted it to replace the Dragon Eye. Within the last few years, the USMC also began employing the Scan Eagle, which can operate for fifteen hours, and has improved ISR sensors.[107] US Army brigades operated both Pioneer and Shadow UAS. The Pioneer UAS continued to operate with virtually no changes to the system, and the Army phased Pioneer out during the ongoing conflicts. Shadow replaced Pioneer, and provided a better ISR platform with a sixty-eight mile range and two hours of loiter time. Finally, Divisions and higher employed the Hunter and Warrior UAS. Hunters performed well during high intensity conflict in Iraq in 2003, but struggled to be effective during subsequent stability and counterinsurgency operations because of the limited range and coverage area of its sensors. In spite of these limitations, the US Army added the Viper Strike munition to the Hunter system in 2004, making it a multi-purpose platform.[108]

Beyond their organic UAS capabilities, the US Army and USMC relied on joint platforms, specifically the Predator, to fill remaining operational needs. ISR demands exceeded joint capacity, so in 2004 the US Army acquired a Predator variant known as Warrior in an effort to boost organic ISR capacity. By 2008, the Army upgraded the Warrior, increasing its payload and making it lethal. In addition to supporting ground units, the Warrior and Sky Warrior changed Army aviation tactics with the advent of manned-unmanned teaming. The UAS acquired targets for OH-58 and AH-64 helicopters. During this acquisition time, the manned aircraft were on strip alert, instead of airborne searching for targets. Once the UAS acquired the targets,

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[107] Department of Defense, *Unmanned Systems Roadmap, 2007–2032* (Washington, D.C.: 10 December 2007), 88; Mark Daley and Martin Streetly, eds, *Jane's Unmanned Aerial Vehicles and Targets, Issue 30* (Alexandria, VA: Odyssey Press, May 2008), 251-253.

[108] Blom, 110.

operators alerted the helicopters to attack. This new tactic resulted in a more efficient process. As the Army expanded its UAS capability, they found it easier to synchronize UAS support with maneuver operations.[109] However, expanding organic UAS capability by the US Army and USMC revealed issues with UAS C2, as well as interoperability.

Ground units typically task organize based on mission needs. It is no different with UAS as commanders task UAS to support small tactical units, or pool them at higher command levels depending on operational needs. For example, during the invasion of Iraq in 2003, the Combined Forces Land Component Commander (CFLCC) C-2 controlled all land component UAS operations to facilitate the integration of UAS capabilities with other intelligence sources. Conversely, subsequent stability and counterinsurgency operations generally required a more decentralized approach, leading to assigning UAS to smaller tactical units.[110] As the US Army and USMC acquired increasingly capable platforms, they needed to operate above the coordinating altitude. This required coordination with the Combined Forces Air Component Commander (CFACC), which took time, and reduced the responsiveness of organic UAS.[111] There is no simple solution to this challenge of balancing the JFC's needs with the needs of tactical ground commanders. Currently joint doctrine for command and control of air operations provides C2 guidance for UAS operations.

UAS intelligence sharing also presented challenges. During the initial stages of OIF, the USMC could not broadcast its Pioneer UAS feed on the Global Broadcast System. The Army's One System Ground Control Station (GCS) provided the solution. The USMC acquired the Shadow UAS, and by using the US Army's GCS, overcame this challenge. Additionally, this

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[109] Blom, 108-109.

[110] Blom, 116, 128.

[111] Kappenman, 21.

common GCS made it possible for adjacent US Army and USMC units to share UAS assets.[112] As difficult as intelligence sharing was initially, processing ISR data proved to be a bigger issue.

The challenge with collecting large quantities of ISR data is twofold. First, as operational routines become established, maneuver units often task UAS based on available capability instead of unit requirements. In some instances, maneuver units failed to update target folders or provide UAS operators with the most up to date information about ground operations. Consequently, UAS repeatedly observed the same Target Areas of Interest (TAIs) with poor results.[113] Second, ISR data requires analysis and distribution to the users who ultimately need it. The growing number of organic UAS compounds the problem of the overwhelming quantity of ISR information.[114] Without effective analysis and distribution, UAS information can become constraining.

Future Vision

The vision for UAS operations by land forces looks similar to current operations. While UAS are a force multiplier for all commanders, ground forces focus on enabling lower echelon, tactical commanders. This approach is logical given the future threat that land forces anticipate.

The US Army does not expect to see a near-peer competitor to their force in the next twenty-five years. Because of that, UAS supporting land forces do not need to be capable of operating in contested airspace.[115] Similar to OEF and OIF, land forces anticipate that future battlefields will remain non-linear and ambiguous. Consequently, UAS development by the US

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[112] Blom, 111, 116.

[113] Kyle Greenberg, "Unmanned Aerial Systems: Quality As Well As Quantity," *Military Review*, July – August 2010, 52-53.

[114] Blom, 128.

[115] US Army, *Eyes of the Army: U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035* (Washington, D.C.: 2010), 19- 20.

Army and USMC focuses on supporting the lowest level tactical commander's ability to achieve information and decision superiority through ISR and RSTA.

The US Army's UAS development strategy focuses on three areas. First, training and developing UAS operators. Second, standardizing equipment through the One System Ground Control Station (OSGCS) and the One System Remote Video Transceiver (OSRVT) to ensure interoperability. Third, developing doctrine centered on the expanding capabilities of the Raven, Shadow, and Sky Warrior UAS.[116] This approach looks to reduce risk to soldiers, reduce soldier's workload by performing routine missions, and extending range of reconnaissance operations.[117] To summarize, the US Army looks to employ UAS across tactical echelons supporting both Army and joint operations, while providing the warfighter a disproportionate advantage through near-real time situational awareness, and multi-role capabilities on demand (including communications, reconnaissance, and armed response).[118]

According to the US Army, OEF will continue to dominate land force UAS development for the next three to five years. This translates into a significant ISR focus in support of companies, battalions, and brigades. To accomplish this, the US Army is expanding the capacity of Shadow platoons, which will increase operational capability by twenty-five percent. Additionally, the US Army will continue to field the Sky Warrior multi-purpose UAS, and expand manned-unmanned teaming operations with AH-64 and OH-58 helicopters.[119] Finally, the USMC is developing a cargo UAS capable of cycling five tons of supplies between a support base and remote outpost over a twenty-four hour period.[120]

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[116] *U.S. Army Aviation: Balancing Current and Future Demands*, 4.

[117] *Eyes of the Army: U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, 5.

[118] *Eyes of the Army: U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, 7.

[119] *Eyes of the Army: U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, 33-46.

[120] US Marine Corps, *U.S. Marine Corps Concepts and Programs 2011: America's Expeditionary Force in Readiness* (Washington, D.C.: 2011), 182.

The five to ten year development window is a little more robust. UAS will continue to represent the majority of the ISR capability in US Army aviation. However, UAS will become increasingly more prevalent as an attack platform. The US Army will field an armed aerial scout that will be increasingly lethal during this time. Additionally, both the US Army and the USMC will also be fielding a sustainment and cargo UAS. In spite of these material developments, the critical component of UAS development is a well-trained professional UAS operator. Part of personnel development includes a commissioned officer UAS career track, or additional skill identifier. The Army vision combines the increased skill of personnel with technological advances in autonomous operations, allowing a single operator to control multiple aircraft.[121] Finally, the USMC will incorporate Electronic Attack (EA) capability into future UAS as part of a broader plan to address the eventual retirement of the EA-6B. The plan distributes EA capability across manned and unmanned platforms. According to the USMC, "[t]he system-of systems-approach allows the nation to move away from low-density/high-demand assets (like the EA-6B) and make electronic warfare ubiquitous across the battlespace."[122]

Significance to Operational Art

The historical context of UAS development by land component forces demonstrates two items of note. First, small tactical UAS pursued throughout the Cold War show the primary purpose of UAS for soldiers and marines is to support tactical maneuver units through ISR or RSTA. Technological developments during the 1970s and 1980s expanded the role of UAS into a fires support platforms as well. This tactical support focus continues in contemporary operations and provides a potential explanation for the delay in expanding UAS into multi-mission platforms, even when the capability existed. Second, the Aquila UAS program shows that small

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[121] *Eyes of the Army: U.S. Army Unmanned Aircraft Systems Roadmap 2010-2035*, 50-56.

[122] *U.S. Marine Corps Concepts and Programs 2011*, 182.

tactical UAS can be expensive propositions where the development cost ultimately outweighs the operational benefit.[123]

Contemporary operations highlight the importance of UAS to ground commanders as ISR platforms, and the critical nature of effective UAS C2 and interoperability. OEF and OIF demonstrate how land forces use UAS to support tactical ground commanders by improving their situational understanding and allowing them to make better decisions faster.[124] However, this desire for more ISR, or more importantly the presence of it, does not always lead to a more effective operational tempo. In some cases ground commanders are either so reliant on UAS that they are hesitant to act without them, or more broadly, the massive amount of information generated by ISR platforms as a whole is not being transformed into intelligence.[125] In these cases, UAS create an unintended consequence, degrading operational tempo, because the information that they produce has its own friction that the unit must overcome.[126] This challenge exists for all commanders. Therefore, it is discussed in further detail in the conclusion of this monograph.

The increase in demand for UAS capability during OEF and OIF resulted in an expansion of UAS capacity. With that expansion, C2 and interoperability challenges emerged. The US Army and USMC addressed many of the interoperability issues for smaller tactical UAS by standardizing UAS inventory and equipment like ground control stations. This allows adjacent units to benefit from one another's UAS capabilities. The C2 challenge highlighted an old source of tension between air and land component forces, and is subsequently discussed in further detail from the JFC's perspective.

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[123] Blom, 69-70.

[124] *U.S. Army Aviation: Balancing Current and Future Demands*, 11.

[125] Blom, 121; Greenberg, 54.

[126] Kipp, Jacob W. and Lester W. Grau. "The Fog and Friction of Technology." *Military Review*, Sept - Oct 2001, 94-95.

Current operations largely shape the future vision of UAS operations by land forces. With that foundation, there are three points of note as land forces develop UAS. First, the US Army and USMC will continue to standardize small tactical UAS equipment and operations. This standardization will improve interoperability and create redundancy. The result is a reduction in risk to mission. Second, ground forces plan to expand UAS capacity, specifically with medium or Group 4 aircraft like Sky Warrior, Fire Scout, and a tactical cargo UAS. By increasing organic capacity, land component commanders reduce reliance on joint force assets, and potentially mitigate risk to mission. However, unless there are significant changes to joint doctrine, this expanded capacity will require continued coordination between air and land component forces. Finally, the US Army plans to create a more professional cadre of UAS soldiers, by making organization and training changes. Lightning Bug operation during the Vietnam War demonstrate the importance of professional expertise in UAS operations. As the US Army expands its higher performance Group 4 UAS inventory, this is a necessary and important step in preventing premature culmination of UAS operations.

Maritime Component

The USN dominates UAS development and operations for maritime use, but that effort does not appear to be as robust as the other services. Historically, USN UAS development focused on utility missions, maritime ISR, and support to naval gunfire. Additionally, during the 1980s, the USN led some sophisticated ISR UAS development efforts that failed to reach operational status. However, until recently the USN has not pursued UAS development for carrier operations in a substantial way. As the DOD shifts its focus towards the Asia-Pacific region, the USN faces a threat to the force projection capability of its carrier battle group as long as it does not have a long range, low observable strike platform. Unmanned Combat Aerial Systems (UCAS) are one possible way to address this challenge, and negate a risk to the USN's mission.

History

UAS development by the USN in the early Cold War era began in 1953. Unlike the other services, the Navy focused its early efforts on unmanned helicopters. Its first UAV was a utility aircraft named Kaman that the USN originally designed for pilot training. However, developers envisioned it performing a variety of utility and surveillance missions. Kaman had some promising initial test flights; however, it was limited to flight within visual range of the aircraft operator. The USN's next program, the Drone Anti-Submarine Helicopter (DASH), was more ambitious. The Navy designed DASH to increase the strike capability of older destroyers against submarines. Unlike the Kaman, DASH utilized sonar and radar to operate beyond visual range. The USN continued to develop these UAVs, but it ultimately canceled UAV programs in 1969 because of a series of crashes.[127]

Shortly after cancellation, the USN revived DASH for operations in the Vietnam War. The Navy used DASH in a RSTA role. It flew over the North Vietnamese coast identifying targets and adjusting fire for five-inch Navy guns.[128] While the USN did not extensively develop UAS during the early Cold War era, or employ them during the Vietnam War, sailors understood UAS development as an area with growth potential. A 1973 sea power article laid out many of the "the possible benefits of UAVs which continue to be echoed by UAV advocates today: lower cost and less risk for pilots."[129]

During the 1980s, the USN made three significant contributions to UAS development. Amber and Condor were two UAV programs that the Navy, in conjunction with Defense Advanced Research Project Agency (DARPA), developed in secret. Amber was a medium altitude, over the horizon platform designed for launch out of a torpedo tube, or from a

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[127] Blom, 52-54.

[128] Newcome, 87.

[129] Blom, 55.

conventional runway. It was originally conceived of as a RSTA platform (possibly for Tomahawk cruise missile targeting); however, the Navy developed a lethal version as well. In 1988, Amber flew a forty-hour endurance demonstration flight at altitudes exceeding 25,000 feet.[130] While Amber did not survive beyond the testing stage, its importance lies in its successful flight demonstrations that paved the way for future medium altitude RSTA platforms. In many ways, Amber is the grandfather of modern platforms like Predator and Reaper.

The Condor program was revolutionary for its time also, as it sought to address the challenge of fleet defense against Soviet bombers. The Backfire Soviet bomber carried anti-ship cruise missiles, capable of being launched outside of the carrier air wing's range. Condor was one-half of a long-range fleet defense system. It was designed to loiter for up to a week near potential Backfire ingress routes. Once it acquired incoming bombers, it cued long-range missile launchers to intercept the bombers. Condor never entered service, but proved invaluable as a technology test bed. In addition to its advanced flight control systems, high-speed computers, and composite structures, Condor airframes utilized advanced propulsion concepts and successfully flew a sixty-hour endurance mission, reaching 67,000 feet.[131]

Pioneer was the third and most successful program that the Navy participated in during the 1980s. Pioneer is a small tactical UAV designed by Israel as a fires observation platform. The Navy acquired it from the Israelis as an off the shelf system and successfully employed it in support of Naval surface fires from 1986 to 2002. During Operation DESERT STORM, the USN deployed two Pioneer detachments to the Persian Gulf on board the USS Missouri and USS Wisconsin battleships. The USN used Pioneer to direct naval gunfire onto shore and monitor Iraqi troop movements. Iraqi army units began to realize that the presence of a Pioneer signaled an

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[130] Curtis Peebles, *Dark Eagles: A History of Top Secret US Aircraft Programs* (Novato, CA: Presidio, 1995), 207-208.

[131] Ehrhard, 22.

incoming artillery barrage. At one point, a group of Iraqi soldiers surrendered to a Pioneer.[132] Even though the Navy retired it in 2002, the USMC continues to use Pioneer as a tactical reconnaissance platform.

UAS development throughout the late 1980s and 1990s occurred with very little additional input from a maritime perspective. The 1988 DOD Master Plan for UAV Development showed that the USN organized UAS into three categories, destroyer/fast frigate support, battleship battle group support, and carrier battle group support. Primary missions included RSTA on sea and land in support of amphibious operations, communications relay, and electronic attack. Carrier battle groups required the most robust support at ranges in excess of 350 nautical miles.[133] In spite of these stated requirements, the USN did not act aggressively to develop UAS to meet these needs.

The history of UAS development by sailors is somewhat limited, and arguably counter-intuitive. The USN achieved some success with DASH, but never developed another system to any degree of significance. Its most successful UAS program, the Pioneer, was an off the shelf purchase that did not clearly match the operational needs outlined in the 1988 Master Plan for UAV Development. Additionally, it is somewhat ironic that in the USN, where the carrier battle group is the premier strike platform, UAS development efforts focused around battle ships and frigates, and supported operations typically separate from the carrier strike group.[134]

Contemporary Operations

UAS operations for maritime missions related to OEF and OIF were not substantial. During this timeframe, the USN was involved in some development efforts related to UCAS, and

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[132] Blom, 72-73, 88, 90.

[133] Department Of Defense, *DOD Joint UAV Program Master Plan*, 1988, 20-21.

[134] Thomas P. Ehrhard, and Robert O. Work, *The Unmanned Combat Air System Carrier Demonstration Program: A New Dawn for Naval Aviation?* (Washington, D.C.: Center for Strategic and Budgetary Assessments, 2007), 12.

broad area maritime surveillance UAS. However, the Navy did not utilize these systems extensively to support OEF and OIF. The following section addresses the USN's efforts in pursuit of both unmanned systems.

Future Vision

Within the next ten years, the continued development of Chinese A2/AD capability threatens the USN's ability to maneuver and project power from the sea. Nuclear aircraft carriers represent a significant portion of the Navy's power projection capability. To remain operationally relevant, the carrier air wing will have to increase its range, persistence, and stealth. Utilizing manned aircraft, carrier air wings can optimally strike targets within 450 nautical miles of the carrier. In fact, the operational reach of a carrier air wing in 2020 will be roughly equivalent to that of a 1980s air wing, which struggled with the proposition of facing the 1970s era Soviet land based air defense system. "In other words, for the first time since the 1980s, and for only the second time since the end of World War II, US carrier strike forces will be faced with a major land-based threat that outranges them."[135]

UAS have a potential role in expanding naval capability in this challenging operational environment. The USN's UAS development focuses on carrier and expeditionary strike groups, and envisions "a diverse UAS portfolio and an architecture for the battlespace awareness, maritime domain awareness, force protection, and force application required by commanders."[136]

Short-range UAS development focuses on utility aircraft and fielding the naval variant of the RQ-4 Global Hawk. The MQ-8B Fire Scout is a helicopter UAS designed to operate from all air capable ships. It represents a Group 4 aircraft capable of providing ISR, RSTA, and C2 support as well as support to mine, anti-submarine, and anti-surface warfare missions.

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[135] Ehrhard and Work, 2, 17, 25, 28.

[136] US Navy, *Naval Aviation Vision* (Washington, D.C.: January 2010), 67.

Additionally, the USN continues to develop a vertical UAS as a replacement for Shadow after 2015. It is primarily a USMC support asset from sea bases, and provides ISR and RSTA capability. Additionally, the USN recently began fielding the naval variant of the RQ-4 Global Hawk called Broad Area Maritime Surveillance (BAMS). This is a land-based platform that compliments the current P-3 Orion capability.[137]

Within ten years, the USN's UAS development has two major efforts. First, the USN plans to continue developing its persistent BAMS capability with a more sophisticated Global Hawk variant. Second, the Unmanned Combat Air System-demonstrator (UCAS-D) program is trying to develop technologies for carrier-capable, low-observable UAS. Ideally, UCAS-D will usher in an acquisition program that could reach initial operational capability around 2025.[138] Once airborne, the UCAS-D follow-on will possess similar capabilities to the USAF's future medium sized UAS. However, UCAS-D employment hinges on its ability to integrate into carrier flight deck operations. This includes catapult launches, arrested landings, flight deck movement, and integration into the carrier air wing's C2, information, and communications systems.[139] The operational system that follows UCAS-D will significantly expand the carrier air wing's range, persistence and stealth capability.

Significance to Operational Art

The history of UAS development by sailors reveals a tendency to focus on utility missions and naval gunfire support. Throughout the 1970s and early 1980s, when the Soviet Air Forces represented a possible threat to the USN, it expanded its UAS development into more advanced systems designed to provide early warning. Both development efforts demonstrate the USN's desire to reduce operational risk through UAS. Of note is the absence of UAS

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[137] *Naval Aviation Vision*, 70.

[138] *Naval Aviation Vision*, 72.

[139] Ehrhard and Work, 34.

development for carrier operations. The technological limitations of the time offer one explanation. However, this absence is also a possible sign of a bigger tendency within the USN that fails to think of UAS as a means of projecting force.

UAS operations of significance by naval forces in Afghanistan and Iraq are virtually non-existent. This is not surprising as USN carrier aviation has made the most substantial contributions to OEF and OIF, and the USN has not historically pursued UAS development for carrier operations.

The future vision for UAS development and operations by maritime forces reveals a continued focus on utility missions, as well as using UAS to increase ISR capability. The development of the MQ-8 Fire Scout for naval utility missions is consistent with early USN UAS programs like Kaman. While technological advances make the Fire Scout more capable, as it is designed for ISR missions as well, it will still operate in very similar ways as Kaman. Likewise, the recent employment and future development of BAMS parallels the Condor program of the 1980s in many ways. As force enablers and ISR platforms, BAMS and Fire Scout improve a naval commander's situational understanding, facilitating a faster operational tempo. However, these programs do not adequately address the potential challenge facing the USN in the future.

The Joint Operational Access Concept describes a potential operating environment in which an enemy uses technologically advanced weapons to deny access or freedom of action in a geographic area. The challenge for future military forces revolves around projecting military force into this A2/AD environment.[140] Historically, the carrier is the power projection arm of the USN. However, the lack of stealth and limited range of USN aircraft limit their utility in an A2/AD environment where USN carriers will face a land-based threat that currently outranges its ability to project military force.[141] The USN is developing the UCAS-D as a potential way to

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[140] *JOAC*, 9, 14.

[141] Ehrhard and Work, 28.

address this challenge, but a low observable, carrier capable, strike UAS will not be operational until 2025 at the earliest.[142] Conversely, DOD strategic guidance calls for a joint force capable of implementing the JOAC in 2020.[143] While the USN has other power projection platforms, there is a risk that until the USN acquires an operational version of the UCAS-D, or something with similar capabilities, this shortcoming will negate the effectiveness of the carrier.

CONCLUSION

The history of UAV operations in the US military is almost as old as the aircraft itself. However, it has only been within that last twenty years that UAS have gained prominence within the force structure. OEF and OIF in particular demonstrate an exponential growth in the use of UAS. Using a case study methodology, this monograph examined historical context, contemporary operations, and the future vision of UAS operations from the perspectives of the air, land, and sea domain to examine the impact of UAS on joint operational art in the US military.

Each of the services has a slightly different perspective on UAS, but none is more divergent from the other services than the USAF. The US Army, USN, and USMC tend to view UAS as a force enabler. Thus, UAS development and operations by these services is primarily for ISR and utility missions. The USAF does not make as great of a distinction between UAS and manned aircraft, therefore as it looks to the future, the USAF is more aggressive in expanding the role of UAS beyond mission support. This fundamentally different perspective on UAS operations has the potential to create friction between the various services.

Joint C2 of UAS is one such challenge created by different service perspectives on UAS operations. During OEF and OIF, the US Army acquired increasingly capable UAS because joint

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142 *Naval Aviation Vision*, 72.

143 *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense*, 1, 4-5.

UAS platforms were not always available to meet the US Army's demand.[144] This reinvigorated the age-old tension between air and land forces on how to organize, command, and control air operations in support of land forces. The desire of supported commanders to control forces that support them is not new and not unique to land forces. Likewise, the constraints imposed by the nature of low-density/high-demand capabilities are also not new, and not unique to air forces. In 2008, the DOD published a Joint Concept of Operations for UAS that used existing doctrine for C2 of joint air operations as guidance for UAS C2. In doing so, the DOD reaffirmed the responsibility of the airspace control authority to manage and be aware of integration issues for all UAS. Most small tactical UAS do not appear on the air tasking order (ATO) and services use coordinating altitudes or other measures to manage the systems. However, UAS that fly above the coordinating altitude are required to appear on the ATO, and are managed using the same positive or procedural control measures used for manned aircraft.[145] This addresses the issue for now, however, if UAS really are different from manned aircraft, should C2 doctrine for joint air operations evolve as well? The answer to that question is beyond the scope of this monograph, but may serve as an interesting topic for future research.

In spite of some differences, the services tend to gravitate towards those characteristics that make UAS unique, in particular, their ability to reduce risk to aircrew, and their extreme persistence.[146] This unique nature of UAS help JFCs extend their operational reach in several ways. First, Lightning Bug operations in Vietnam demonstrate the tradition of using UAS in a high threat environment where a commander would not normally send a manned platform. This allows that commander to affect the area of operations in a way that was not possible before UAS. Second, HVT strikes in places like Pakistan and Yemen allows a JFC to pursue enemy

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[144] Kappenman, 20.

[145] *Joint Concept of Operations for Unmanned Aircraft Systems*, III-10 – III-11.

[146] *Joint Concept of Operations for Unmanned Aircraft Systems*, I-2.

forces in areas that would otherwise be a safe haven. By denying enemy forces a sanctuary, JFC's are able to seize or retain the initiative in geographic areas where military operations were not possible before UAS. Furthermore, operational reach is not only a matter of distance, but also a matter of duration.[147] The extreme persistent potential of UAS, both large and small, to endure over long durations may prove to be transformative.

Risk reduction, and extended operational reach give JFCs an opportunity to seize the initiative in ways not possible before UAS. Additionally, UAS provide immense amounts of information, theoretically improving a JFCs understanding of the battlefield. This combination of information and understanding should facilitate decision superiority and a faster operational tempo. However, more information does not mean better information. Ultimately, UAS are only useful when employed effectively.

At no time in history, has a military commander had more information about the battlefield than one does today, and there are some that think this may ultimately reach the point where commanders are omniscient.[148] UAS are one aspect of a broader system of information platforms designed to provide a commander with this all-knowing perspective. However, as Clausewitz described the concept of fog in war, he said that gaining accurate information is not easy as "many intelligence reports in war are contradictory; even more are false, and most are uncertain."[149] In fact, sometimes too much information produces its own kind of friction as it can be distorted and produce uncertainty about reality.[150] Antoine Bousquet examined this concept using the Vietnam War and further explains that "misperceptions and uncertainties in military

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[147] JP 5-0, III-33.

[148] Willian A. Owens with Edward Offley, *Lifting the Fog of War* (Baltimore, MD: Johns Hopkins University Press, 2001), 14.

[149] Carl von Clausewitz, *On War,* Translated by Michael Howard and Peter Paret (Princeton, NJ: Princeton University Press, 1976), 117.

[150] Alan Beyerchen, "Clausewitz, Nonlinearity, and the Unpredictability of War," *International Security* 17, No. 3, 1992, 77.

affairs are fuelled by an inability to distinguish relevant from false information (signal from noise) and excess volumes of data can hinder more than assist in this."[151] The result is often micro-management and the illusion of control where operational commanders become increasingly involved in tactical decision-making, and lose sight of the operational and strategic aspects of the situation for which they are responsible.[152] Additionally, reliance on large volumes of information can generate vulnerabilities.[153] Commanders can either become cognitively paralyzed when that information is not available (as previously demonstrated), or the centralization of information and decision-making can stifle initiative at lower levels. History indicates that this is generally inadequate in military organizations as it becomes self-defeating.[154]

Indeed, UAS possess the potential to facilitate a faster operational tempo for commanders because of the way they extend operational reach and reduce risk. However, their mere presence does not guarantee this. Like any tool, UAS are only as effective as the military professional that operates them.

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[151] Antoine Bousquet, *The Scientific Way of Warfare: Order and Chaos on the Battlefields of Modernity* (New York, NY: Columbia University Press, 2009), 198.

[152] Milan Vego, "Net-Centric Is Not Decisive," *Proceedings* 129, No. 1, 2003, 56.

[153] Bousquet, 234.

[154] Martin Van Creveld, *Command in War* (Cambridge, MA: Harvard University Press, 1985), 269.

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